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<p>(21) International Application Number: <b>WO/99/1599/07230</b></p> <p>(22) International Filing Date: 1 April 1999 (01.04.99)</p> <p>(30) Priority Data: 60/080,708 3 April 1998 (03.04.98) US</p> <p>(71) Applicant (for all designated States except US): E.I. DU PONT DE NEMOURS AND COMPANY [US/US]; 1007 Market Street, Wilmington, DE 19898 (US).</p> <p>(72) Inventors; and</p> <p>(73) Inventors/Applicants (for US only): MANOQUE, William, H. [US/US]; 224 Beverly Road, Newark, DE 19711 (US). NAPPA, Mario Joseph [US/US]; 3 Cambridge Court, Newark, DE 19711 (US). SIEVERT, Allen, Capron [US/US]; 219 River Lane, Elkton, MD 21921 (US).</p> <p>(74) Agent: HEISER, David, E.; E.I. du Pont de Nemours and Company, Legal/Patent Records Center, 1007 Market Street, Wilmington, DE 19898 (US).</p>		<p>(81) Designated States: AE, AL, AU, BA, BB, BG, BR, CA, CN, CU, CZ, DE, GE, HR, HU, ID, IL, IN, IS, JP, KP, KR, LC, LK, LR, LT, LV, MG, MK, MN, MX, NG, NZ, PI, RO, SG, SI, SK, SL, TR, TT, UA, US, UZ, VN, YU, ZA, ARPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UD, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TI, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BI, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p>Published With international search report.</p>	
<p>(54) Title: PROCESS FOR THE PRODUCTION OF FLUOROCARBONS</p> <p>(55) Abstract</p> <p>A process is disclosed for the manufacture of hexafluoropropylene and 1,1,1,2,3,3-heptafluoropropane. The process involves (A) feeding 1,1,2-trichloro-1,3,3-trifluoropropene, HF and Cl<sub>2</sub> to a first reaction zone containing a catalyst comprising trivalent chromium and operating at a temperature of at least 250 °C, but not more than about 325 °C, to produce a reactor effluent comprising C<sub>3</sub>Cl<sub>2</sub>F<sub>6</sub>, C<sub>3</sub>CCl<sub>2</sub>FCF<sub>3</sub>, HCl and HF. The reactor effluent of (A) may be distilled to produce (i) a low boiling stream including HCl; (ii) a reactant stream including an azeotrope of 2-chloro-1,1,1,2,3,3-heptafluoropropane and HF and (iii) a high-boiling stream including a reactant stream including an azeotrope of 2-chloro-1,1,1,2,3,3-heptafluoropropane of reactant stream (ii) may be reacted with hydrogen in the presence of C<sub>3</sub>Cl<sub>2</sub>F<sub>6</sub> and C<sub>3</sub>Cl<sub>2</sub>F<sub>3</sub>. The 2-chloro-1,1,1,2,3,3-heptafluoropropane of reactant stream (ii) may be fed along with HF to a second reaction zone containing a catalyst comprising trivalent chromium and operating at a temperature of at least about 375 °C to produce a reaction product comprising C<sub>3</sub>CCl<sub>2</sub>FCF<sub>3</sub> and HF. The reactor product from the second reaction zone may be recycled to the first reaction zone.</p>			

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TITLE

**PROCESS FOR THE PRODUCTION  
OF FLUOROCARBONS**  
**FIELD OF THE INVENTION**

5 The present invention relates to the synthesis of hexafluoropropylene and  
1,1,1,2,3,3-heptafluoropropane.

BACKGROUND

Commercial methods for the preparation of hexafluoropropylene ( $\text{CF}_3\text{CF}=\text{CF}_2$  or HFP), a fluoromonomer, typically involve temperatures greater than 600°C. The high reaction temperatures lead to the formation of perfluoroisobutylene, an extremely toxic compound which is costly to remove and destroy (e.g., see European Patent Application No. 002,098). Processes for the manufacture of HFP at lower temperatures based on the use of acyclic three-carbon hydrocarbons or partially halogenated three-carbon hydrocarbons are disclosed in U.S. Patent Nos. 5,043,491, 5,057,634 and 5,068,472.

10 1,1,1,2,3,3,3-Heptafluoropropane ( $\text{CF}_3\text{CHFCF}_3$  or HFC-227ea), a fire extinguishant, can be prepared by the reaction of HF with HFP in contact with activated carbon (e.g., see British Patent Specification No. GB 902,590). The manufacture of HFC-227ea in this instance is tied to the availability HFP.

15 There is a need for alternative methods of manufacturing HFP and HFC 227ea.

SUMMARY OF THE INVENTION

A process is provided for the manufacture of hexafluoropropylene and 1,1,1,2,3,3-heptafluoropropane. The process comprises (a) feeding 1,1,2-trichloro-3,3,3-trifluoropropene-1 ( $\text{CCl}_2-\text{CClCF}_3$ ), HF and  $\text{Cl}_2$  to a first reaction zone containing a catalyst comprising trivalent chromium and operating at a temperature of at least 250°C, but not more than about 325°C, to produce a reactor effluent comprising  $\text{C}_3\text{Cl}_1\text{F}_5$ ,  $\text{C}_3\text{Cl}_2\text{F}_6$ ,  $\text{CF}_3\text{CClFCF}_3$ ,  $\text{HCl}$  and HF; (b) distilling the reactor effluent of (a) to produce (i) a low boiling stream comprising  $\text{HCl}$ , (ii) a reactant stream comprising an azeotrope of 2-chloro-1,1,1,2,3,3-heptafluoropropane HF and (iii) a high-boiling stream comprising  $\text{C}_3\text{Cl}_2\text{F}_6$  and  $\text{C}_3\text{Cl}_3\text{F}_5$ ; (c) reacting the 2-chloro-1,1,1,2,3,3-heptafluoropropane of reactant stream (ii) with hydrogen in the presence of a catalyst to produce a mixture comprising hexafluoropropylene and 1,1,1,2,3,3-heptafluoropropane; (d) feeding the  $\text{C}_3\text{Cl}_2\text{F}_6$  and  $\text{C}_3\text{Cl}_3\text{F}_5$  of high boiling stream (iii) along with HF to a second reaction zone containing a catalyst comprising trivalent chromium and operating at a temperature of at least about 375°C to produce a reaction product comprising  $\text{CF}_3\text{CClFCF}_3$  and HF; and (e) recycling the reaction product of (d) to the first reaction zone.

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BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a schematic flow diagram of an embodiment of the process of this invention.

DETAILED DESCRIPTION

5 The present invention involves the use of  $\text{CCl}_2=\text{CClCF}_3$  and  $\text{CF}_3\text{CClFCF}_3$  in combination as materials for producing  $\text{CF}_2=\text{CFCF}_3$  and  $\text{CF}_3\text{CHFCF}_3$ . The process of the Invention uses an azeotropic composition of  $\text{CF}_3\text{CClFCF}_3$  and HF as a precursor to the desired products. Further information on such azeotropes is provided in U.S. Patent Application No. [CL-1158-P1], which is hereby incorporated by reference herein.

10  $\text{Cl}_2=\text{CCl}_2\text{CF}_3$ , a feed material for step (a) above, may be derived, for example, by the chlorofluorination of hexachloropropylene. At least a portion of the  $\text{CF}_3\text{CClFCF}_3$  is derived in accordance with step (d) above.

Figure 1 is illustrative of one method of practicing this invention.

15 Referring to Figure 1, a feed mixture comprising hexachloropropylene (i.e.,  $\text{CCl}_2=\text{CCl}(\text{CCl})_2$  or HCP), chlorine and hydrogen fluoride and where the HF:HCP molar ratio is about 3:1, or more (the  $\text{Cl}_2:\text{HCP}$  ratio is typically about 1:1, or more), is passed through line (110) into reactor (100). Liquid phase, vapor phase or trickle bed reactors can be used. For the liquid phase and trickle bed reactors 20 the reaction temperature is at least about 25°C. The trickle bed reactors are usually packed, e.g., with carbon, or can contain bubble trays; both modes are well known in engineering practice. For the vapor phase reactors, which can be either empty or packed (e.g., with carbon), the minimum reaction temperature is at least 150°C. The  $\text{CCl}_2=\text{CClCF}_3$  starting material of step (a) can also be obtained by 25 the chlorofluorination reaction of 2-fluoropropane over a divalent cobalt on an activated carbon catalyst as described in U.S. Pat. No. 3,865,885.

The reactor effluent from chlorofluorination reactor (100) comprising 1,1,2-trichloro-3,3,3-trifluoropropene-1 (i.e.,  $\text{CCl}_2=\text{CClCF}_3$  or FC-1213xa), chlorine, HF and HCl is passed through line (120) into line (510) where it is combined with the reaction effluent from reactor (500). The reactor (500) effluent comprises 2-chloro-1,1,1,2,3,3-heptafluoropropane (i.e.,  $\text{CF}_3\text{CClFCF}_3$  or FFC-217ba), HCl and HF.

30 The combined (100) and (500) reactor effluents are sent to reactor (200) which is maintained at a temperature within the range of about 250°C to about 325°C. Reactor (200) is packed with a catalyst comprising trivalent chromium. Additional HF may be added, if required. A preferred catalyst is  $\text{Cr}_2\text{O}_3$  prepared by the pyrolysis of  $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$  as described in U.S. Patent No. 5,036,036.

35 The reactor (200) effluent comprising HF,  $\text{C}_3\text{Cl}_4\text{F}_5$ ,  $\text{C}_3\text{Cl}_2\text{F}_6$  and  $\text{C}_2\text{ClF}_7$  is sent through line (210) into distillation column (300). The  $\text{C}_3\text{Cl}_4\text{F}_5$  component

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is mainly composed of  $\text{CClF}_2\text{CCl}_2\text{CF}_3$ ,  $\text{CCl}_2\text{FCClFCF}_3$  and a small amount of  $\text{CClFCF}_2\text{CClF}_2$ . The  $\text{C}_3\text{Cl}_2\text{F}_6$  component is mainly composed of  $\text{CF}_3\text{CCl}_2\text{CF}_3$  and  $\text{CClF}_2\text{CClFCF}_3$  and small amounts of  $\text{CClF}_2\text{CF}_7\text{CClF}_2$ . The  $\text{C}_3\text{ClF}_7$  component is mainly composed of  $\text{CF}_3\text{CClFCF}_3$ . HCl and other low boiling components are removed through line (320) and the remainder of the reactor (200)

5 components are sent through line (310) into a second distillation column (400). The effluent is sent through line (430) into reactor (500) which is maintained at a temperature of at least about 375°C. The reactor is packed with a catalyst comprising trivalent chromium. A preferred catalyst is the above-described  $\text{Cr}_2\text{O}_5$  prepared by

10 pyrolysis of  $(\text{NH}_4)_2\text{Cl}_2\text{O}_7$ . The effluent from reactor (500) comprising HCl, HF and CFC-217ba is removed through line (510) and sent to reactor (200).

15 HF/CFC-217ba azeotrope is removed from the top of column (400) through line (410). HF/CFC-217ba azeotrope is passed through line (420) into catalytic reactor (500) along with hydrogen which is fed through line (610). The reactor (600) product is removed through line (620) and comprises, HCl, HF, hexafluoropropylene (i.e.,  $\text{CF}_3\text{CF}=\text{CF}_2$  or HFP) and 1,1,1,2,3,3,3-heptafluoropropane ( $\text{CF}_3\text{CHFCF}_3$  or HFC-227ea). The hydrogenolysis of step (c) may be conducted in the presence of HF. HFP and HFC-227ea can be isolated by conventional means. A portion of the azeotrope can be taken off through line (410) for other uses (e.g., the manufacture of  $\text{CF}_3\text{CF}_2\text{CF}_3$ ).

20 The fluorination catalyst employed in steps (a) and (d) of the process of the invention may be supported or unsupported. Any of the fluorination catalysts described in the prior art may be used such as oxides, halides and oxyhalides of aluminum, cobalt, manganese, iron and particularly chromium. Suitable 25 chromium-containing catalysts include oxide, hydroxide, oxyhalide, halides, inorganic acid salts, basic chromium fluorides and especially preferred are the chromium oxide catalysts described in U.S. Pat. No. 5,036,036. The catalysts may be given a prefluorination treatment by passing hydrogen fluoride, with or without an inert diluent such as nitrogen, over the catalyst at a temperature within 30 the range of about 250 to 450°C prior to use.

The operating pressure of the process of the invention is dependent on the product isolation scheme employed and is generally within the range of from about 101 kPa to about 5000 kPa.

35 The reaction zone of steps (a) and (d) may consist of one or two reactors. CFC-217ba may be reacted with hydrogen to form a product comprising HFP and HFC-227ea by contacting the CFC-217ba with hydrogen at an elevated temperature in the vapor phase over a catalyst comprising at least one component selected from the group consisting of elemental metals, metal oxides, metal

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halides and metal oxyhalides; wherein the metal of said hydrodehalogenation catalyst component is selected from copper, nickel, chromium and mixtures thereof and the halogen of said halides and said oxyhalides is selected from fluorine, chlorine and mixtures thereof. Greater details of the reaction with hydrogen are described in U.S. Patent No. 5,057,634 which is incorporated herein by reference. Another useful catalyst comprises a three-dimensional matrix carbonaceous material such as that described in U.S. Patent No. 4,978,649.

5 Alternatively, CFC-217ba can be converted to a product comprising HFC-227ea and HFP by contacting CFC-217ba with hydrogen at an elevated 10 temperature in the vapor phase over a catalyst comprising at least one metal selected from the group consisting of rhodium, ruthenium, rhodium and palladium. The reaction temperature for these metal-containing catalysts is at least about 100°C. The reaction temperature when other catalysts are used is normally at least about 300°C. In any case, the reaction temperature is normally 15 less than 500°C.

The reaction pressure is normally within the range of about 100 kPa to about 7000 kPa. Typically, the mole ratio of hydrogen to CFC-217ba is from 0.5:1 to 25:1, preferably from 1:1 to 5:1.

Those skilled in the art will recognize that since the drawings are 20 representational, it will be necessary to include further items of equipment in an actual commercial plant, such as pressure and temperature sensors, pressure relief and control valves, compressors, pumps, storage tanks and the like. The provision of such ancillary items of equipment would be in accordance with conventional chemical engineering practice.

25 The reaction zone and its associated feed lines, effluent lines and associated units should be constructed of materials resistant to hydrogen fluoride and hydrogen chloride. Typical materials of construction, well-known to the fluorination art, include stainless steels, in particular of the austenitic type, the well-known high nickel alloys, such as Monel® nickel-copper alloys, Hastelloy® nickel-based alloys and, Inconel® nickel-chromium alloys, and copper-clad steel.

30 Without further elaboration, it is believed that one skilled in the art can, using the description herein, utilize the present invention to its fullest extent. The following specific embodiments are, therefore, to be construed as merely 35 illustrative, and do not constrain the remainder of the disclosure in any way whatsoever.

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EXAMPLESLEGEND

13	is $\text{CClF}_3$	23 is $\text{CHF}_3$
112	is $\text{CCl}_2\text{FCCl}_2\text{F}$	113 is $\text{CCl}_2\text{FCClF}_2$
5	114 is $\text{CClF}_2\text{CClF}_2$	115 is $\text{CClF}_2\text{CF}_3$
	125 is $\text{CHF}_2\text{CF}_3$	214ab is $\text{CCl}_2\text{FCl}_2\text{CF}_3$
	215aa is $\text{CClF}_2\text{Cl}_2\text{CF}_3$	215bb is $\text{CCl}_2\text{FCClFCF}_3$
	215ca is $\text{CCl}_2\text{FCF}_2\text{CClF}_2$	216aa is $\text{CF}_3\text{CCl}_2\text{CF}_3$
	216ba is $\text{CClF}_2\text{CClFCF}_3$	216ca is $\text{CClF}_2\text{CF}_2\text{CClF}_2$
10	217ba is $\text{CF}_3\text{CClFCF}_3$	217ca is $\text{CClF}_2\text{CF}_2\text{CF}_3$
	218 is $\text{CF}_3\text{CF}_2\text{CF}_3$	226da is $\text{CF}_3\text{CHClCF}_3$
	226ea is $\text{CClF}_2\text{CHFCF}_3$	227ea is $\text{CF}_3\text{CHFCF}_3$
	236ea is $\text{CHF}_2\text{CHFCF}_3$	236fa is $\text{CF}_3\text{CH}_2\text{CF}_3$
15	1213xa is $\text{CCl}_2=\text{CClCF}_3$	1214 is $\text{C}_3\text{Cl}_2\text{F}_4$
	1215 is $\text{C}_3\text{ClF}_5$	1215xa is $\text{CF}_2=\text{CClCF}_3$
	1225zc is $\text{CF}_2=\text{CHCF}_3$	HFP is $\text{CF}_3\text{CF}=\text{CF}_2$
	CT is contact time	P is pressure
	T is temperature	

General Procedure for Product Analysis

20 The following general procedure is illustrative of the method used. Part of the total reactor effluent was sampled on-line for organic product analysis using a total reactor effluent was sampled on-line for organic product analysis using a 20' (6.1 m) long x Hewlett Packard HP 3890 gas chromatograph equipped with a 20' (6.1 m) long x 1/8" (0.32 cm) diameter tubing containing Krytox® perfluorinated polyether on an inert carbon support and within a flame ionization detector. The helium flow was 35 mL/min. Gas chromatographic conditions were 70°C for an initial hold period of three minutes followed by temperature programming to 180°C at a rate of 6°C/minute.

25 The bulk of the reactor effluent containing organic products and also inorganic acids such as HCl and HF was treated with aqueous caustic prior to disposal.

EXAMPLE 1Chlorofluorination of FC-1213xa

30 Chromium oxide (47.25 g, 35 mL, 10-20 mesh, (2.0-0.84 mm)), obtained from the pyrolysis of ammonium dichromate prepared according to the procedure described in U.S. Pat. No. 5,036,036, was placed in a 5/8" (1.58 cm) diameter Inconel® nickel alloy reactor heated in a fluidized sand bath. It was heated to 175°C in a flow of nitrogen (50 cc/min) at which time HF flow (50 cc/min) was also started through the reactor. After 15 minutes, the nitrogen flow was decreased to 20 cc/min and the HF flow increased to 80 cc/min. The reactor

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temperature was gradually increased to 400°C during a 2 hour period and maintained at 400°C for an additional 30 minutes. At the end of this period the reaction was brought to the desired operating temperature for catalyst evaluation under a nitrogen flow.

5 The results of the chlorofluorination reaction are shown in Table 1 in area %.

TABLE I

T °C	Molar Ratio HF:1213xa:Cl <sub>2</sub>	C.T. Sec.	% 217ba	% 226da	% 216aa	% 216ba	% 215aa	% Others
250	20:1:2	60	0.3	1.8	10.1	9.9	74.9	3.0
260	20:1:2	60	0.5	2.5	15.6	10.8	67.8	2.8
260	20:1:4	60	0.5	0.7	10.6	13.2	77.4	2.6
260	10:1:2	60	0.2	0.5	5.7	9.7	82.4	1.7
260	20:1:4	30	0.3	0.8	8.5	11.8	76.2	2.3
275	20:1:2	30	1.1	2.5	23.4	12.4	47.8	2.8
275	20:1:2	60	1.0	2.8	37.8	11.2	54.9	2.4
275	20:1:4	15	1.5	1.1	16.0	14.9	64.4	2.1
300	10:1:2	30	1.3	1.1	45.7	9.5	40.9*	1.5
300	20:1:2	30	3.1	1.9	48.0	12.8	31.6	2.2
300	20:1:2	15	3.4	2.7	45.4	11.4	34.6	2.1
325	6:1:2	30	3.9	0.0	30.7	9.7	4.7	1.0

Others include mostly 1215, as well as 113, 114, 115, 1214, 215ca, 216ca and 217ca.

10

EXAMPLE 2Chlorofluorination of FC-1213xa

The reactor used in Example 1 was charged with a 20% CrCl<sub>3</sub>/carbon catalyst (6.15 g, 15 mL, 10-20 mesh, (2.0 0.84 mm)), prepared as described in Example 1 of U.S. Pat. No. 3,632,834, and activated as described above in

15 Example 1.

The contact time for each run was 15 seconds. The results of the chlorofluorination reaction are shown in Table 2 in area %.

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T °C	Molar Ratio HF:1213xa:C <sub>2</sub> F <sub>5</sub>	TABLE 2							
		% 216aa	% 216ba	% 1214	% 215aa	% 215bb	% 1213xa	% 214ab	% Others
300	20:1:4	4.0	0.2	6.5	19.5	6.0	61.3	0.0	1.9
325	20:1:4	8.7	0.5	3.7	34.1	7.1	39.7	0.0	1.3
325	20:1:2	14.6	0.4	3.7	36.1	6.6	37.2	0.0	1.4
350	20:1:4	16.1	1.0	3.1	50.7	7.9	0.0	19.1	1.9
350	6:1:1	13.6	0.5	2.5	51.9	4.3	1.2	25.0	1.2

Others include mostly 1215, as well as 13, 112, 113, 216ca, 226da and

217ha.

EXAMPLE 3Fluorination of FC-216aa

The reactor and catalyst treatment were the same as those described in

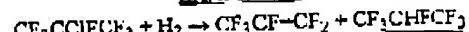
Example 1. A fresh sample of chromium oxide catalyst was used.

The contact time for each run was 30 seconds. The results of the

fluorination reaction are shown in Table 3 in mol %.

T °C	Molar Ratio HF:216aa	TABLE 3					
		% 218	% 217ba	% 1215	% 226da	% 216aa	% Others
375	4:1	0.2	7.4	0.6	0.7	90.2	0.8
400	4:1	0.6	18.2	0.7	0.9	78.7	0.9
400	8:1	0.6	22.2	1.0	0.9	74.5	0.8
400	12:1	0.6	23.8	1.3	0.9	72.4	0.9
400	20:1	0.6	28.2	1.8	1.7	66.5	1.2
425	20:1	1.3	53.7	1.6	1.7	39.7	1.9

Others include mostly 23, 115, 125, 1214, 1215, 227ca, 216ba and 217ca.

EXAMPLE 4

A 15" (38.1 cm) X 3/8" (0.95 cm) O.D. Inconel™ 600 nickel alloy U-tube

reactor was charged with 6% Re/acid-Washed Carbon (2.4 g, 6.25 mL). The

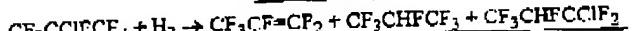
H<sub>2</sub>:CFC-217ba molar ratio was 2:1. Results (in mol %) at various conditions are shown in Table 4.

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TABLE 4

T °C	P psig (kPa)	CT min	% Conv. 217ba	% Sel. HFP	% Sel. 1225ec	% Sel. 237ea	% Sel. 226ca	% Sel. Other
260	0 (101)	1.1	100	23	0.6	71	3.7	1.3
260	38 (363)	1.3	98	18	0.6	73	6.6	1.3
260	100 (791)	1.1	80	16	0.5	76	6.2	1.3
380	0 (101)	1.0	100	25	1.7	68	2.6	2.3
280	30 (308)	1.0	100	18	1.8	71	6.4	3.0
280	100 (791)	2.1	100	7	2.8	69	16.4	4.5
300	0 (101)	0.3	100	25	1.6	69	2.0	2.2
300	0 (101)	0.5	100	26	2.4	67	1.7	2.9
300	0 (101)	1.0	100	23	4.0	66	1.7	4.4

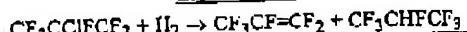
EXAMPLE 5

A 15" (38.1 cm) X 1/4" (0.64 cm) O.D. Hastelloy™ C-276 nickel alloy

- 5 U-tube reactor was charged with 1% Ru/Acid-Washed Carbon calcined at 925°C (2.59 g, 6.25 mL). The reaction pressure was 0 psig (101.3 kPa). Results (in mol %) at various conditions are shown in Table 5.

TABLE 5

T °C	Mol H <sub>2</sub> /217ba	CT sec.	% Conv. 217ba	% Sel. HFP	% Sel. 227ea	% Sel. 236fa	% Sel. 226ca	% Sel. Other
325	2	31	100	4	43	1.5	43.4	8.0
325	2	16	80	18	36	0.6	42.0	3.6
350	2	15	85	18	36	1.2	40.1	5.5
325	4	30	76	29	40	0.9	27.2	3.3
325	4	6	23	58	35	0.2	4.1	3.1
350	4	6	24	59	32	0.7	3.0	4.5
350	4	3	6	67	24	0.9	0.4	7.7
360	4	3	5	64	25	1.1	0.2	9.9

EXAMPLE 6

- A 15" (38.1 cm) X 3/4" (0.95 cm) O.D. Inconel™ 600 nickel alloy U-tube reactor was charged with 1% Ru/Acid-Washed Carbon (1.9 g, 6.25 mL). The reaction pressure was 0 psig (101.3 kPa). Results (in mol %) at various conditions are shown in Table 6.

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TABLE 6

T °C	Mol H <sub>2</sub> :217ba	CT min.	% Conv. 217ba	% Sel. HFP	% Sel. 227ea	% Sel. 226ea	% Sel. Other
200	4	0.30	84	7	74	5	13
175	4	0.32	46	10	72	4	15
213	2	0.30	81	9	75	6	9
200	1	0.31	50	15	74	5	6

EXAMPLE 7

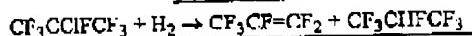
A 15" (38.1 cm) X 1/4" (0.64 cm) O.D. Inconel™ 600 nickel alloy U-tube

5 reactor was charged with carbon which was a three-dimensional matrix carbonaceous material (2.36 g, 6.25 mL, 20-30 mesh (0.84-0.59 mm)). The reaction pressure was 0 psig (101.3 kPa) for the first Table 7 entry and 30 psig (208 kPa) for all the others. The H<sub>2</sub>:CFC-217ba molar ratio was 4:1 for the first entry and 16:1 for all the others. Results (in mol %) at various conditions are

10 shown in Table 7.

TABLE 7

T °C	CT min.	% Conv. 217ba	% Sel. HFP	% Sel. 227ea	% Sel. 226ea	% Sel. 1215xc
350	0.10	10	65	27	4	0.9
350	0.12	11	61	28	8	0.8
370	0.12	12	61	27	9	1.0
400	0.12	15	59	27	10	1.2
400	0.06	12	68	24	5	0.7
425	0.06	14	68	24	5	0.8
475	0.05	24	63	27	7	0.7
450	0.05	13	62	31	5	0.4
450	0.11	13	52	40	6	0.4

EXAMPLE 8

15 The same reactor and catalyst as used for Example 7 was used. The reaction pressure was 0 psig (101.3 kPa) and the H<sub>2</sub>:CFC-217ba molar ratio was 4:1. Results (in mol %) at various conditions are shown in Table 8.

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*Carbon*

TABLE 8

T °C	CT min.	% Conv. 217ba	% Sel. HFP	% Sel. 227ea	% Sel. 236ca	% Sel. 1215xe	% Sel. Others
325	0.10	14	43	20	2	0.7	1.6
350	0.10	11	62	28	4	1.2	2.6
350	0.05	9	65	27	5	0.9	3.0
350	0.50	9	56	32	6	2.4	4.4

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CLAIMS

1. A process for the manufacture of  $\text{CF}_2=\text{CFCF}_3$  and  $\text{CF}_3\text{CHFCF}_3$ ,

comprising:

(a) feeding  $\text{CCl}_2=\text{CClCF}_3$ , HF and  $\text{Cl}_2$  to a first reaction zone

5 containing a catalyst comprising trivalent chromium and operating at a temperature of at least  $250^\circ\text{C}$ , but not more than about  $325^\circ\text{C}$ , to produce a reactor effluent comprising  $\text{C}_3\text{Cl}_3\text{F}_5$ ,  $\text{C}_3\text{Cl}_2\text{F}_6$ ,  $\text{CF}_3\text{CClFCF}_3$ , HCl and HF;

(b) distilling the reactor effluent of (a) to produce (i) a low-boiling stream comprising HCl, (ii) a reactant stream comprising an azeotrope of

10  $\text{CF}_3\text{CClFCF}_3$  and HF and (iii) a high-boiling stream comprising  $\text{C}_3\text{Cl}_2\text{F}_6$  and  $\text{C}_3\text{Cl}_3\text{F}_5$ ;

(c) reacting the  $\text{CF}_3\text{CClFCF}_3$  of reactant stream (ii) with hydrogen in the presence of a catalyst to produce a mixture comprising  $\text{CF}_2=\text{CFCF}_3$  and  $\text{CF}_3\text{CHFCF}_3$ ;

15 (d) feeding the  $\text{C}_3\text{Cl}_2\text{F}_6$  and  $\text{C}_3\text{Cl}_3\text{F}_5$  of high-boiling stream (iii) along with HF to a second reaction zone containing a catalyst comprising trivalent chromium and operating at a temperature of at least about  $375^\circ\text{C}$  to produce a reaction product comprising  $\text{CF}_3\text{CClFCF}_3$  and HF; and

(e) recycling the reaction product of (d) to the first reaction zone.

2. The process of Claim 1 wherein the  $\text{CCl}_2=\text{CClCF}_3$  of (a) is derived by the chlorofluorination of  $\text{CCl}_2=\text{CClCCl}_3$ .

3. The process of Claim 1 wherein the hydrogenolysis of (c) is conducted in the presence of HF.

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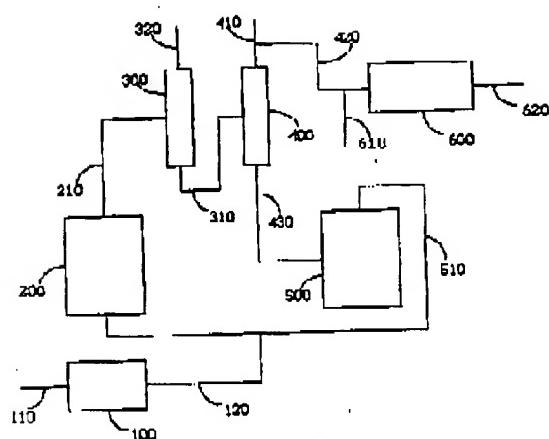
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FIG 1



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## INTERNATIONAL SEARCH REPORT

Int'l Search Application No  
PCT/US 99/07230

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 C07C17/09 C07C17/21 C07C17/23

According to International Patent Classification (IPC) or to your national classification and (PCT)

## B. FIELDS SEARCHED

Minimum documentation searched (Classification system followed by classification symbols)  
IPC 6 C07C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
Y	US 5 043 491 A (WEBSTER JAMES L ET AL) 27 August 1991 cited in the application see the whole document	1-3
Y	EP 0 539 989 A (HOTCHKIS AG) 5 May 1993 see the whole document	1-3

Further documents are listed in the continuation of box C.

Patent family members are listed in Annex.

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Date of the actual compilation of the international search

2 July 1999

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Information on patent family members

Inter. Appl. No.  
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Form PCT/ISA/210 (patent family = true) (July 1992)